Fishery Data Series No. 96-47

Sea-run and Resident Cutthroat Trout and Sea-run Dolly Varden Population Status at Lake Eva, Southeast Alaska, During 1995

by

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and

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December 1996

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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Development of this manuscript was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Projects F-10-10 and F-10-11, Job No. R-1-5.

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This document should be cited as:
Yanusz, Richard J., and Artwin E. Schmidt. 1996. Sea-run and resident cutthroat trout and sea-run Dolly Varden population status at Lake Eva, Southeast Alaska, during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-47, Anchorage.

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ABSTRACT

Suspected declines in cutthroat trout *Oncorhynchus clarki* abundances in Southeast Alaska and a history of thorough research in the 1960s at the Lake Eva system (Baranof Island) prompted a re-examination of the system in 1995. All sea-run cutthroat trout and Dolly Varden *Salvelinus malma* exiting the Lake Eva system between 14 April and 31 July 1995 were counted at a weir on the lake's outlet. A total of 2,562 cutthroat trout and 117,821 Dolly Varden passed downstream through the weir, and were defined as sea-run. These numbers far exceeded the historical emigrations observed in the 1960s at Eva Creek. The mean fork lengths of 303 mm for sea-run cutthroat trout and 304 mm for sea-run Dolly Varden during 1995 were also greater than those recorded during the early 1960s, which were 284 mm and 253 mm fork length, respectively. Dolly Varden age 6 and less in 1995 tended to be larger at age than in 1963. Year-class and other effects contributed to these results. Cutthroat trout present in Lake Eva during July (when adult sea-run trout are essentially absent) were defined as residents, and a two-event, mark-recapture method was used to estimate that 2,154 (SE 274) cutthroat trout ≥180 mm fork length were present. Mean fork length of resident trout ≥180 mm was 240 mm. The density and the length distribution of resident cutthroat trout in Lake Eva did not appear substantially different from other cutthroat trout populations in Southeast Alaska.

Key words: Alaska, Lake Eva, cutthroat trout, Dolly Varden, sea-run, weir, abundance, otolith, age, length, mark-recapture

INTRODUCTION

Concern over suspected declining abundance in Southeast Alaska cutthroat trout *Oncorhynchus clarki* populations (Figure 1) prompted the Alaska Board of Fisheries to adopt more restrictive regulations for cutthroat trout in 1994. Historical data exists for few systems in Southeast Alaska, but extensive research was conducted at the Eva system during the 1960s (Heiser 1966; Armstrong 1971). The availability of this information provided a unique opportunity to contrast the sea-run populations of cutthroat trout and Dolly Varden *Salvelinus malma* at Lake Eva across long time periods. Since Lake Eva was considered largely unexploited during the 1960s, present conditions should provide insight into the effects of increased harvest and environment on the lake's trout and Dolly Varden populations.

The objectives of this project were to 1) enumerate the spring emigration of overwintering Dolly Varden and cutthroat trout from Lake Eva between April and July 1995; 2) estimate the size composition of overwintering Dolly Varden and sea-run cutthroat trout from the spring emigration; 3) estimate the abundance of resident cutthroat trout ≥180 mm fork length in Lake Eva during July 1995 when adult, sea-run cutthroat trout are absent; 4) estimate the size composition of cutthroat trout ≥180 mm fork length in Lake Eva during July 1995 when adult sea-run cutthroat trout are absent; 5) estimate whether potamodromous (continuously resident) cutthroat trout exist in Lake Eva by using otolith microchemistry; and 6) mark fish for the first event of a multi-year Jolly-Seber abundance experiment. We also aged Dolly Varden to enable more comparisons with the historical data (Heiser 1966).

STUDY AREA

The Lake Eva drainage is located on northeastern Baranof Island in Southeast Alaska (Figure 2), and drains into Peril Straits at Hanus Bay (57° 24' 31" N, 125° 4' 3" W). Lake Eva's (anadromous stream catalog number 113-52-10040-0010) surface area is 105 ha and its maximum depth is 22 m (Figure 3). Eva Creek (anadromous stream catalog number 113-52-10040) is approximately 1.5 km long, 20 to 50-m wide, and 0.3 to 2-m deep.

The Lake Eva system is an important over-wintering site for sea-run Dolly Varden and cutthroat trout populations. During 1962-64 an average of 1,346 cutthroat trout (range 1,210 to 1,594) emigrated, and during 1962 and 1963 an average of 66,130 Dolly Varden (range 38,957 to 93,303) emigrated from Lake Eva (Heiser 1966; Armstrong 1971). Sport fishing effort has increased from <10 anglers per year during 1962-64 (Armstrong 1971) to 280 angler-days in 1977 to 551 angler-days in 1993 (Mills 1979-1994). A USDA-Forest Service public use cabin was built on Lake Eva in 1980 and was occupied continuously during the summer of 1995 (personal observation). A foot trail along Eva Creek also received daily use during the spring and summer of 1995 (personal observation).

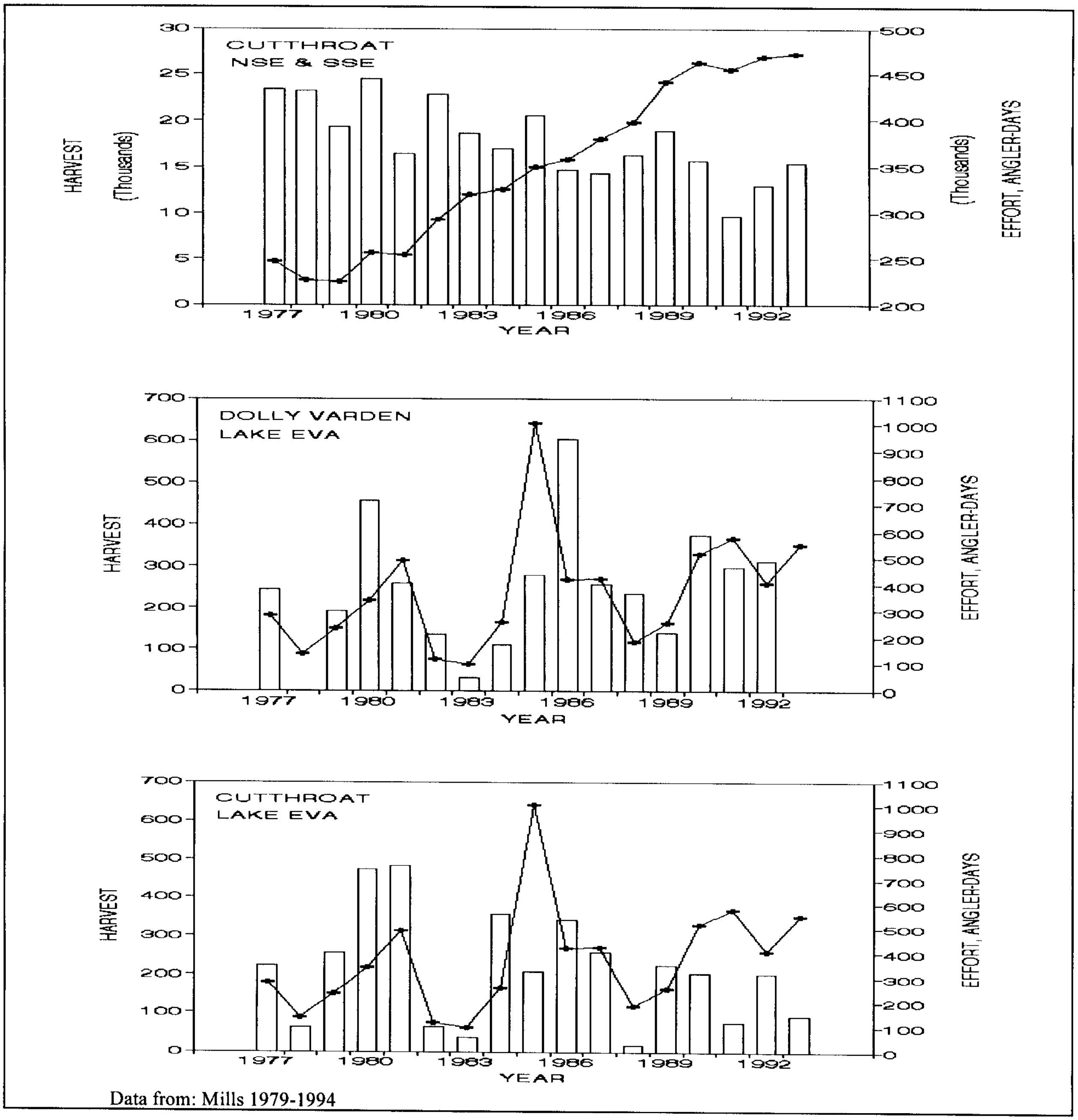

Figure 1.-Harvests of cutthroat trout for all of Southeast Alaska (top), and Dolly Varden (middle) and cutthroat trout (bottom) at Lake Eva, and associated effort, 1977-93. Harvests are represented by bars and effort by lines.

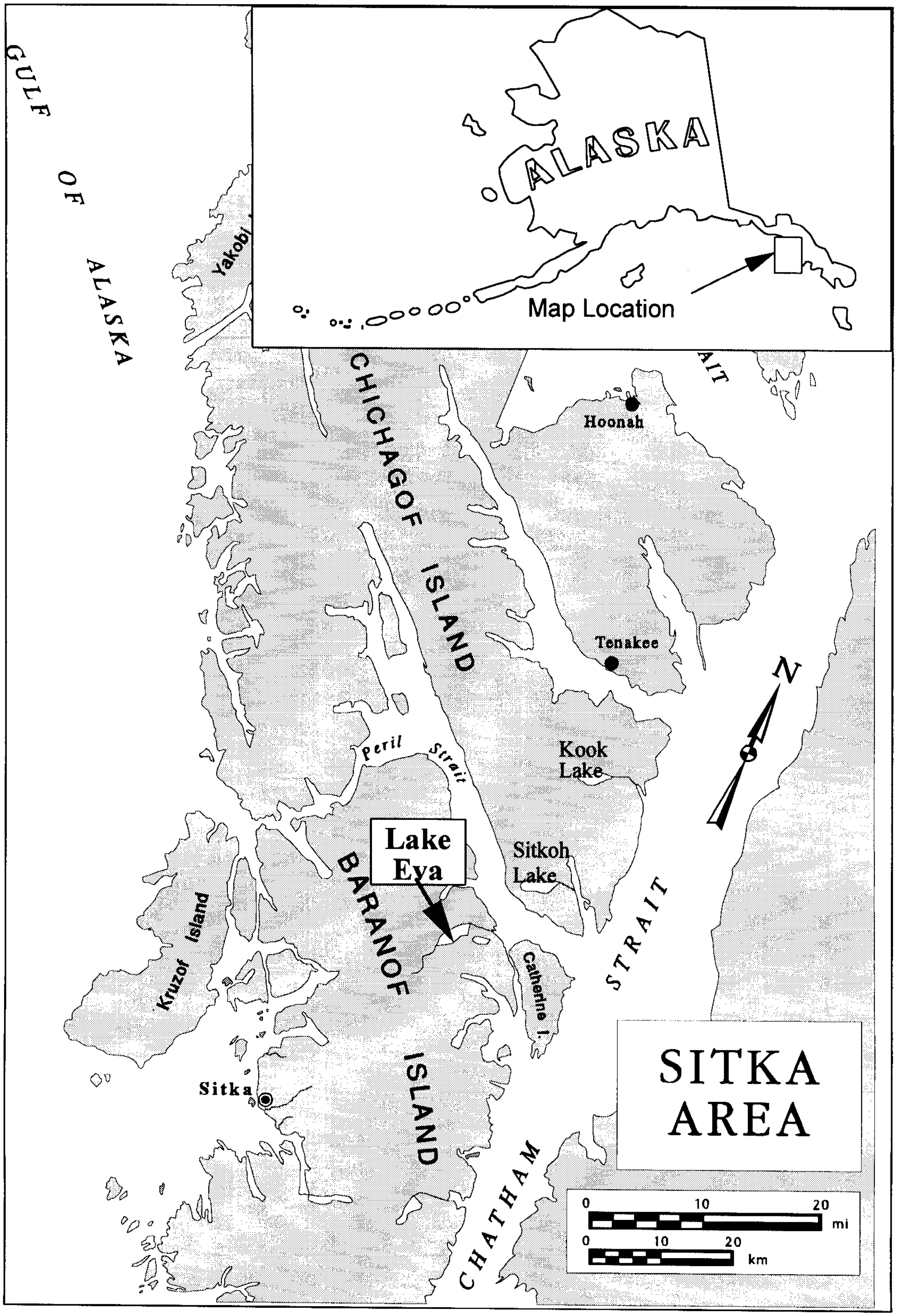

Figure 2.- The location of Lake Eva in northern Southeast Alaska.

Dolly Varden harvests in the Eva system may have increased slightly between 1977 and 1993, while cutthroat trout harvests may have decreased slightly during the same period (Figure 1). The decreasing harvest-per-unit-effort of cutthroat trout may reflect changing angler values (i.e. more catch and release) or somewhat lower abundances.

METHODS

MIGRANT FISH

A weir was placed in Eva Creek approximately midway between Lake Eva and Hanus Bay, at the exact site of the 1962-64 weir (Figure 3). The weir was composed of 18-mm diameter steel pickets with 31-mm maximum gaps between each picket. The upstream face of the weir was overlaid with 1.2 by 2.4-m steel frames covered with 18 by 21-mm rectangular-opening plastic mesh (extruded polyethylene). The mesh and frames were attached to the weir with cable ties, and the entire interface of the mesh and the stream bed was covered with sandbags. This design was significantly different from the historic weir, which was a wooden platform and weighted cribs that supported panels of 16-mm square opening wire mesh (Armstrong 1965, 1971). The Armstrong design was reported to stop Dolly Varden and cutthroat trout >45 mm FL. Traps were placed both on the upstream and downstream sides of the 1995 weir to capture all fish

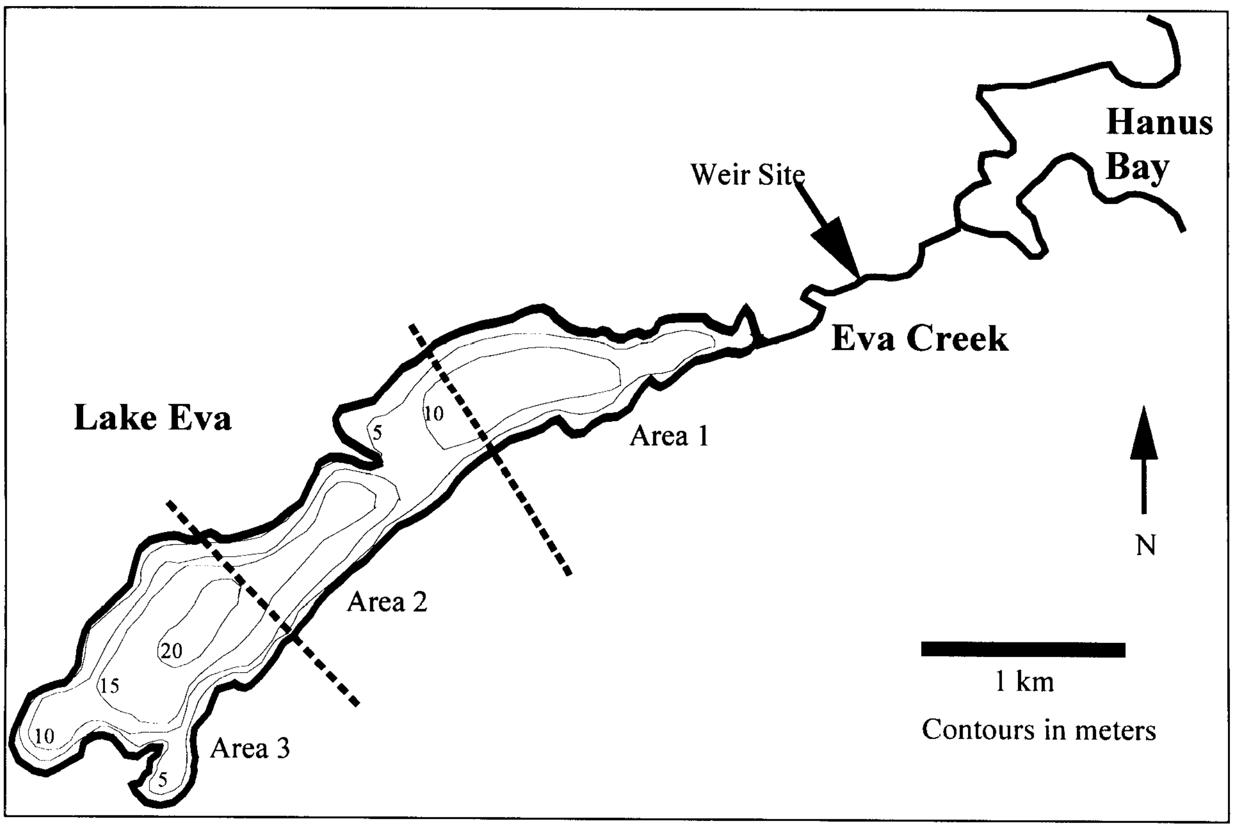

Figure 3.-Lake Eva, Eva Creek and Hanus Bay, showing the weir site and the boundaries of the lake sampling areas. Scale is approximate.

moving either way. The 1995 weir operated continuously from 14 April through 31 July. Weir integrity was checked at least daily, and fish in either trap were processed whenever necessary to avoid crowding. Water temperature and depth were recorded at about 0800 hours each day.

All fish passed through the weir were defined as sea-run. This definition was used because it is consistent with the 1962-64 baseline data and was easy to apply. "Sea-run" is used to describe the cutthroat trout and Dolly Varden migrating between fresh and salt water. These fish usually use saltwater for transportation to adjacent freshwater systems or for seasonal residence, whereas fully anadromous fish, such as steelhead and salmon, remain in salt water a full year or more and visit only one freshwater system. While some fish were observed to remain in lower Eva Creek throughout the summer and never enter salt water, this proportion appeared to be small and was ignored. All cutthroat trout and Dolly Varden not passed through the weir were defined as resident, but obviously include immature fish of both life histories.

Every cutthroat trout ≥180 mm FL passed through the weir was counted, examined for fin clips, tagged with a uniquely-numbered Floy® (T-bar anchor) tag, measured for FL to the nearest 1 mm, had scales collected from the peduncle region (left supro-lateral), and had its adipose fin fully removed as a double mark. Every cutthroat trout <180 mm FL was processed as above except it was not Floy® tagged and its left ventral fin instead of its adipose fin was fully removed.

Every Dolly Varden passed downstream through the weir was counted, and every 200th fish passed was measured for FL to the nearest 1 mm and sacrificed for otoliths (sagittae) to determine its age. Every Dolly Varden passed upstream though the weir was counted, examined for fin clips, and was given a hole punch in its caudal fin to avoid double-counting if the fish moved though the weir repeatedly. Once Dolly Varden moving upstream were marked, every Dolly Varden moving downstream was inspected for the caudal punch.

Otoliths collected from Dolly Varden were cleaned and stored dry. For age determination, otoliths were soaked in a 1% solution of detergent and distilled water for 8-24 h and viewed with a dissecting microscope using a black background, reflected light, and 15X magnification. The number of hyaline (dark) rings were counted and considered to be annuli. These are the identical methods Heiser (1966) used to determine the ages of Lake Eva Dolly Varden. To evaluate reader bias in the otolith aging, we re-read 100 randomly-selected otoliths from the original 1963 sample, and compared both readings. We also located the raw data collected at Eva Creek during the 1960s at the Alaska Department of Administration, Archives and Record Management Services (Appendix A1), to estimate historical Dolly Varden length-frequencies, age compositions, and daily run timing.

Size and age composition of migrant Dolly Varden char was estimated by

$$\hat{p}_i = \frac{a_i}{n}, \tag{1}$$

$$V[\hat{p}_i] = \frac{\hat{p}_i\,(1 - \hat{p}_i)}{n - 1}\,, \tag{2}$$

where $\hat{p}_i$ = estimated proportion of group i (size or age group), a_i = number in group i, and n = number successfully aged or measured for length.

Since all cutthroat trout were measured, the size composition of emigrant cutthroat trout is known. All other species of fish were counted and passed through the weir.

RESIDENT FISH

Considering the historical data for the Eva system, we anticipated that 14 July would be the date of least overlap between the emigrating and immigrating sea-run cutthroat trout (Figure 4). A two-event mark-recapture experiment to estimate the abundance of resident cutthroat trout in Lake Eva was thus conducted around this date. Fish were marked during 2 July to 12 July (event 1), and then sampled for marks during 22 July to 1 August, 1995 (event 2).

Lake Eva's surface was divided into three sampling areas to facilitate testing for the mixing of tagged fish (Figure 3). The number of trap sets (one trap fished overnight) in each area was made in proportion to the lake's surface area, and a total of 130 sets occurred during each sampling event. Distribution of the traps across the lake was determined by overlaying a uniform grid of numbered points across a map of the lake. Points for placing traps were systematically chosen after the first point was randomly chosen. For example, if *p* points were available in area 1 and *t* traps were to be set, the first point was a randomly chosen number between 1 and *p/t*. Once the first point was selected, the remaining traps were systematically placed every *p/t* points from the first point. If *p/t* was not an integer, it was always rounded down, to avoid having too many traps for the number of available points.

Traps were baited with approximately 300 ml of salmon eggs and placed on the lake bottom. Traps were always fished overnight, for 14-24 h. Each trap consisted of a cylindrical, aluminum frame 1.0 m long and 0.6 m in diameter, covered with 6-mm-square opening plastic mesh (extruded polyethylene). At each end was an inward-pointing funnel with a circular opening of approximately 90 mm. The funnels were also constructed of 6-mm-square opening plastic mesh. Additionally, fish were captured with hook and line, using standard sport fishing gear and methods. Hook and line sampling effort was also distributed in proportion to the surface area in each sampling area. All depths within each area were fished by hook and line, but the majority of effort occurred near-shore, at the most productive depths.

During the marking event, every cutthroat trout ≥180 mm FL captured was counted, examined for fin clips, tagged with a uniquely-numbered Floy® tag inserted on the left side immediately below the dorsal fin, measured to the nearest 1 mm FL, sampled for scales from the peduncle region (left supro-lateral), and fin-clipped as a double mark. Fish were allowed to recover and released in the area of capture. Any unusual fish condition (tagging stress) was noted. Cutthroat trout <180 mm FL were processed as above except that Floy tags were not placed.

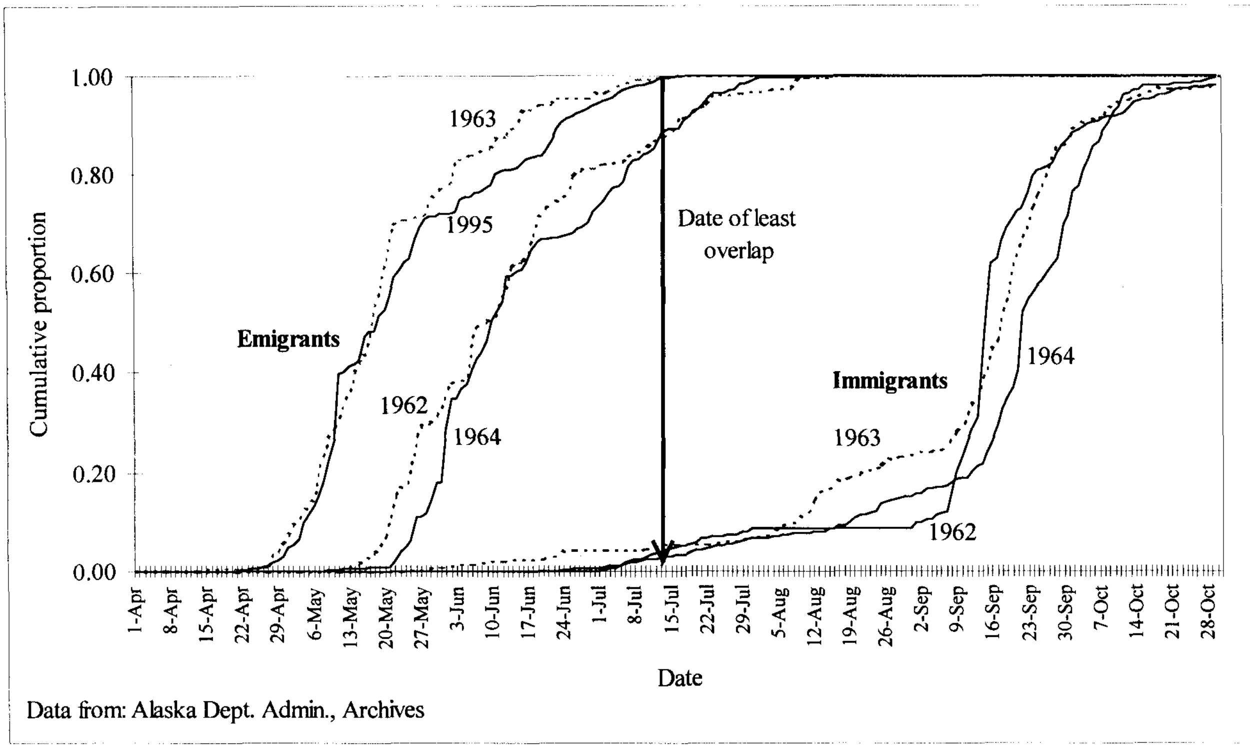

Figure 4.-Timing of the immigration and emigration of sea-run cutthroat trout at Lake Eva during 1962-64 and 1995, showing the date of least overlap of the migrations, 14 July.

During the sampling event , all captures ≥180 mm FL were counted, measured for length, fin clips and tag numbers of marked fish were recorded, and tip of anal fin clips were given to identify redundant captures, should it be captured again. Cutthroat trout marked at the weir were noted but not used in any way for the population estimate. Dolly Varden captured were counted only.

The assumption of complete spatial mixing of marked and unmarked fish ≥180 mm FL between sampling events was tested with a contingency table (chi-square test) comparing the numbers of marked and unmarked fish captured in each area. Size-selectivity among sampling events was tested with a Kolmogorov-Smirnov (K-S) test. Procedures for estimating abundances when sampling is size selective are detailed in Appendix A2. Tag loss and tagging stress were recorded on every fish to ensure they were low. Chapman's modification of the Peterson model was used to estimate the abundance of cutthroat trout ≥180 mm FL,

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1, \tag{3}$$

$$V[\hat{N}] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)}, \tag{4}$$

where $\hat{N}$ = abundance of cutthroat trout ≥ 180 mm FL, n_1 = number of cutthroat trout ≥180 mm FL marked in event 1, n_2 = number of cutthroat trout ≥180 mm FL examined in event 2, and m_2 = number of marked cutthroat trout recaptured in event 2.

The length composition of resident cutthroat trout was estimated by equations 1 and 2 above. Because the assumptions of closely-spaced, Petersen mark-recapture methods for cutthroat trout appear to be violated significantly in some experiments (Robert Marshall, Alaska Department of Fish and Game, Douglas, personal communication), an inter-annual (three year) Jolly-Seber model was added to the experiment, to facilitate greater mixing, lessen behavioral effects, and allow for mortality, recruitment, or emigration between samples. For the Jolly-Seber model, event 1 was a consolidation of events 1 and 2 of the Peterson model during July 1995, event 2 was the fish marked during July 1996, and event 3 will occur during July 1997. This three-event experiment will produce an abundance estimate that will be germane to event 2 (July 1996).

Determination of whether potomodromous cutthroat trout reside in Lake Eva was planned using the methods of Rieman et al. (1994). The usefulness of the Sr/Ca (atomic) ratio in fish otoliths (the sagitta bone of the inner ear) as a marker of anadromy requires that a substantial difference in the Sr/Ca ratio exists between the target freshwater environment and nearby marine environment (Rieman et al. 1994). We assumed the nearby salt water would have a Sr/Ca ratio of 0.0087 (Bruland 1983). On 5 May 1995, two 100-ml water samples were collected from the central basin in Lake Eva, one sample from 1-m deep and the second from 15-m deep. A control sample of distilled water was also analyzed. Each sample was preserved with approximately 0.5 ml of 1:1 nitric acid and stored at room temperature. The Lake Eva samples and a control sample were analyzed by Northern Testing Laboratories (Fairbanks, Alaska) on 7 July 1995, using atomic absorption spectrometry.

RESULTS

MIGRANT DOLLY VARDEN

The total number of Dolly Varden passed downstream through the weir was 117,821 fish (Appendix A3). The first Dolly Varden was captured on 14 April, the daily count peaked on 27 May, the midpoint of the emigration occurred on 15 May, and it was five weeks between the 5th and the 95th percentile of run (Figure 5). Most of the emigration occurred when the water temperature was between 4 and 9°C. High daily counts of emigrant Dolly Varden frequently coincided with high gage heights. The mid-point of the 1995 Dolly Varden emigration fell within those of the historical data, which were 21 May 1962 and 10 May 1963 (Figure 6). A total of 14,196 Dolly Varden were passed upstream through the weir. The upstream migration began on 1 June, and was continuous from 19 June until the weir was removed.

The length distribution of emigrant Dolly Varden in 1995 was bi-modal, with peaks at the 241-260 and 321-340 mm FL categories (Figure 7; Appendix A4). The mean FL of all emigrants

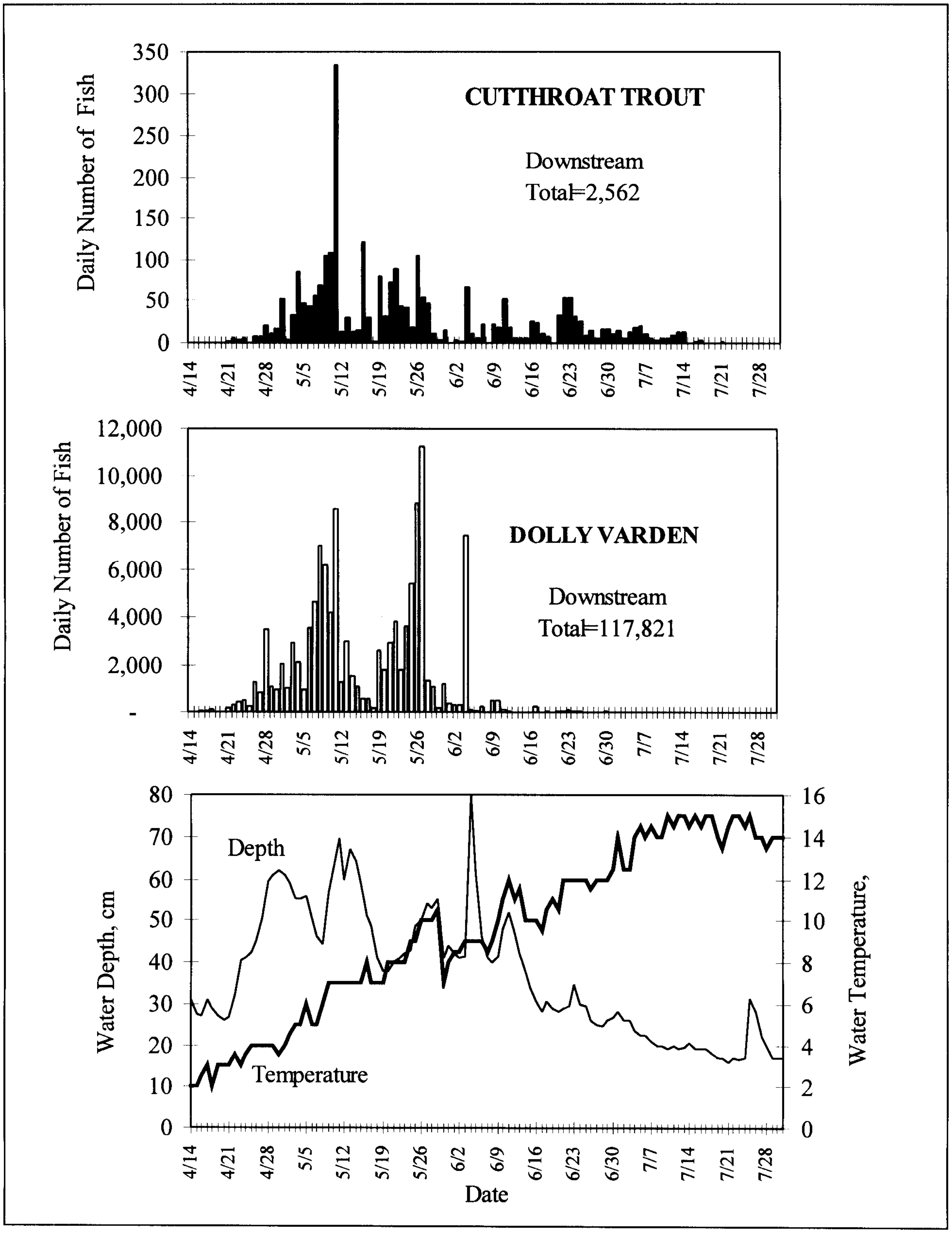

Figure 5.-Daily counts of emigrating Dolly Varden and cutthroat trout and daily water temperature and depth at the Eva Creek weir during 1995.

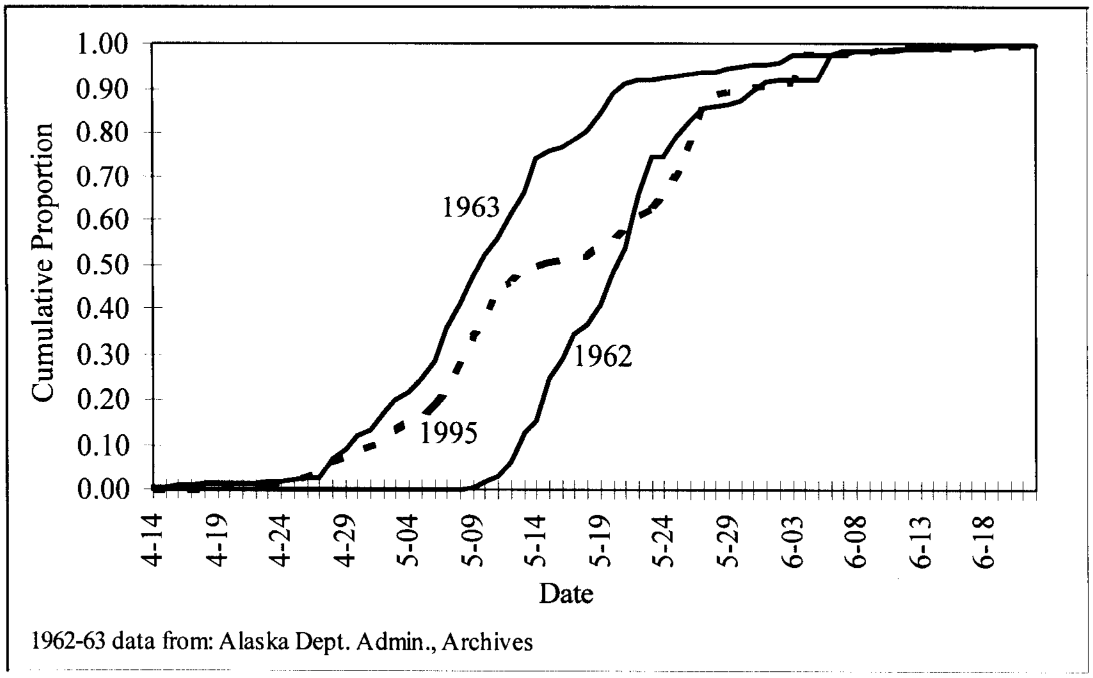

Figure 6.-Timing of the emigration of sea-run Dolly Varden Char at Lake Eva during 1962, 1963 and 1995.

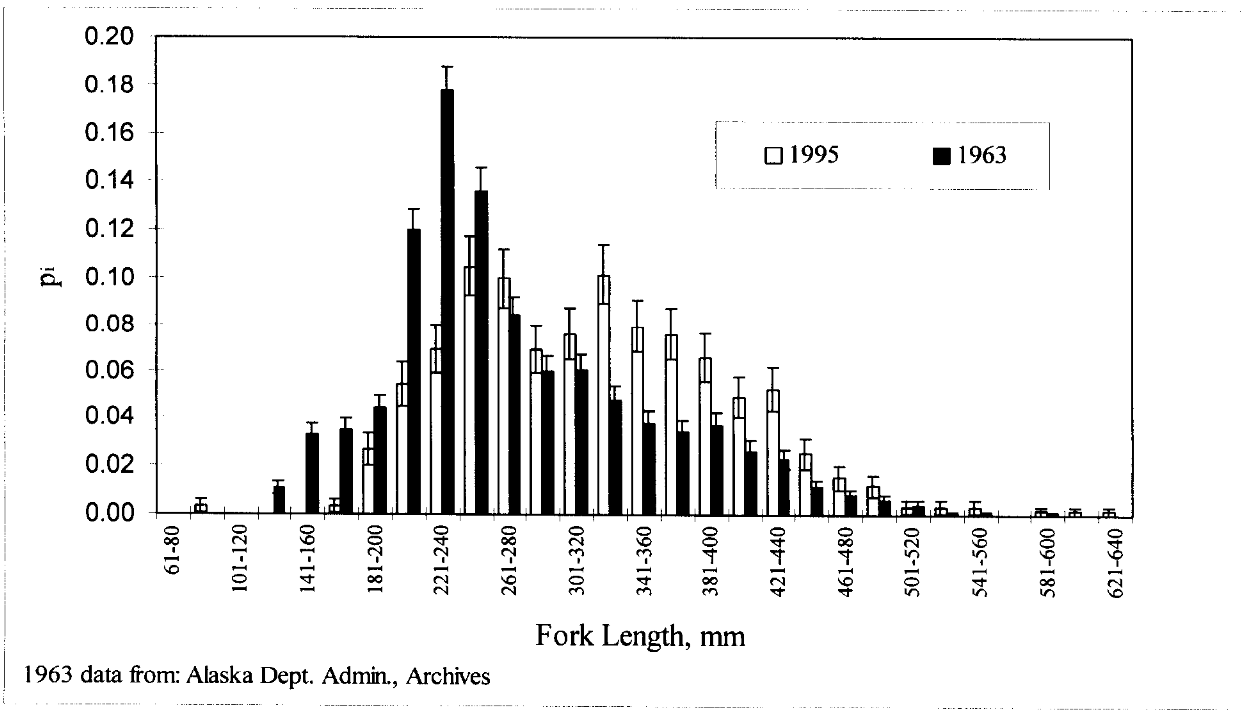

Figure 7.-Length fequency (proportion per 20-mm length category, p_i) of sampled Dolly Varden at the Eva Creek weir during 1963 and 1995. Error bars are ± one standard error.

sampled during 1995 was 304 mm (SE 3.3 mm) and the range was 79 to 620 mm (N=591). The mean FL of all emigrants sampled during 1963 was much smaller at 253 mm (Heiser 1966, N=1,355; Figure 6). The 1995 emigrant Dolly Varden were significantly larger than those in 1963 (K-S test, $P<0.001$, $n_1=1,355$, $n_2=591$, $D_{max}=0.323$).

Mean weekly FL of Dolly Varden in 1995 varied between weeks and did not have a general trend, but in 1963 it decreased steadily (Figure 8). The 1995 weir design appeared to stop all fish ≥150 mm fork length (FL), moving either upstream or downstream. Even with the smaller mesh used in 1963, very few emigrant Dolly Varden were ≤160 mm FL, so the differences in weir designs and mesh size were not considered significant factors in the fish catches (Figure 6). However, uniform sampling was used in the 1963 study (approximately 35 fish every other day), in spite of an apparent trend in FL with emigration time. To assess the impact of the 1963 sampling design, we located the original 1963 data (Appendix A1) and calculated an unbiased estimate of 239 mm for the mean FL in 1963 by weighting the mean FL for each two-day period by the abundance in the two-day period. This further demonstrates the significant differences in the 1995 mean FL estimate (304 mm) and the 1963 mean FL estimate (253 unweighted and 239 mm weighted) for Dolly Varden emigrants.

A total of 591 emigrant Dolly Varden were sampled for age (otoliths) and length during 1995. Of these, 296 otoliths (every other otolith) were read, with 21 judged unreadable. Age 5 was the dominant age class, followed closely by age 4 and age 6 (Table 1; Figure 9), and the age composition appears shifted towards older fish, relative to 1963. Differences in the age composition between 1963 and 1995 are, however, partly a result of differences in how readers assigned age to the otolith patterns (reader bias). In the sample of 100 otoliths selected from the 1963 study, we tended to assign somewhat older ages in 1995, especially for fish age ≥4 according to the 1963 reader (Figure 10).

Robust, quantitative comparisons (with larger sample sizes) of the 1963 and 1995 age compositions were outside the scope of this study. For an exploratory purpose, we adjusted the age composition estimates from 1963 into estimates that account for the 1995 reader's bias. This was done by converting the reader-agreement data (Figure 10) into a transition matrix (dividing each observation by the row total), multiplying numbers at age in the 1963 sample (of 1,355 fish; Table 1) through the matrix, and adding the results by age (column totals), to produce the 1963 age composition from the 1995 reader's perspective.

In contrast to the apparent, unadjusted differences (Table 1; Figure 9), estimates for the dominant age classes 4 (29.7% vs. 26.5%) and 5 (33.8% vs. 31.6%) come into closer agreement for the adjusted 1963 and the 1995 estimates, respectively. The difference for fish aged 6 (in the 1995 reader's eyes), however, remained very different (14.0% vs. 23.3%) for the adjusted 1963 and 1995 estimates. The relative proportions of fish age 2 and 3 and fish age ≥7 did not change greatly. Thus, while the obvious differences in the size of Lake Eva Dolly Varden in 1963 and 1995 (Figure 6) was not well quantified in terms of age, the differences are likely less than suggested in Table 1 and Figure 9 and largely due to the presence of a strong older age class in 1995.

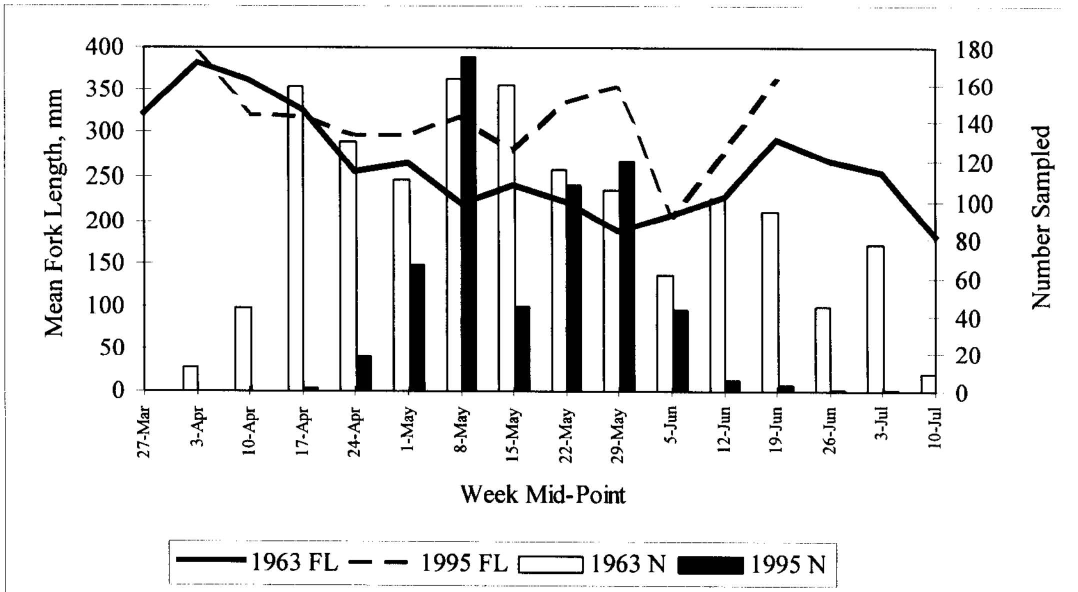

Figure 8.-Weekly mean fork length (FL, lines) and sample sizes (N, bars) of sea-run Dolly Varden leaving Lake Eva during 1963 and 1995.

Table 1.-Estimated mean fork length (FL, in mm) and percent of emigrant Dolly Varden by age at the Eva Creek weir during 1963 and 1995. N is number of fish sampled.

	1995						1963[a]		
	FL						FL		
Age	Mean	SE	Minimum	Maximum	N	Percent	Mean	N	Percent
2					0	0	111	3	0.2
3	179	5	162	192	5	1.8	147	101	7.5
4	233	5	80	348	73	26.5	206	486	35.9
5	293	7	188	443	87	31.6	249	388	28.6
6	325	7	190	450	64	23.3	315	245	18.1
7	370	12	210	514	36	13.1	372	91	6.7
8	368	29	232	475	7	2.5	394	28	2.1
9	354	8	346	362	2	0.7	476	8	0.6
10					0	0	433	4	0.3
11	457		457	457	1	0.4	435	1	0.1
All	295	5	80	514	275	100	253	1,355	100

[a] From: Heiser (1966)

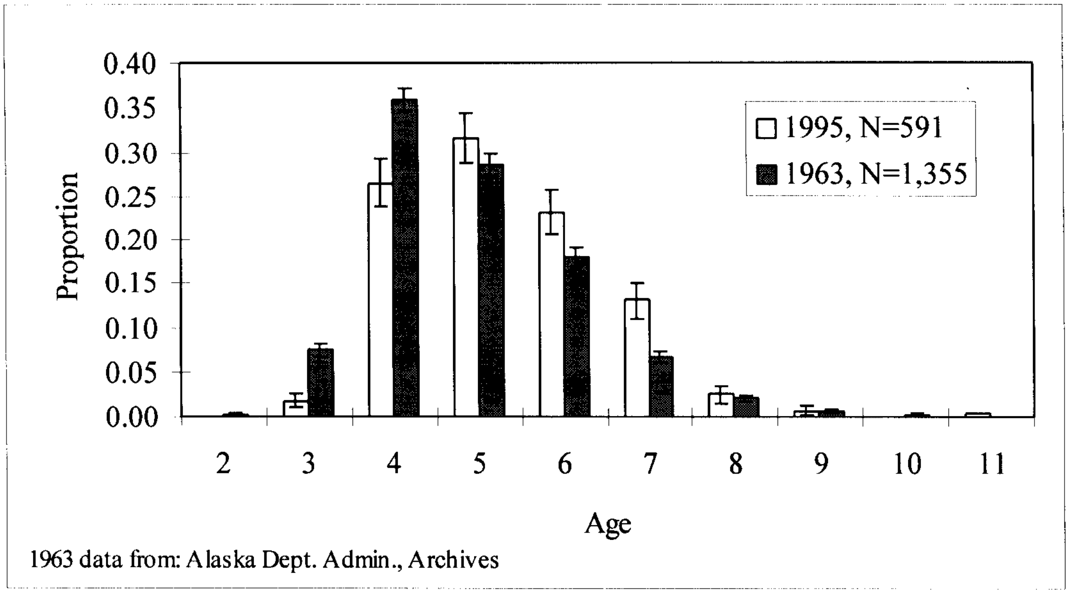

Figure 9.-Estimated, unadjusted age composition of Dolly Varden at Eva Creek during 1963 and 1995 for the full samples. Error bars are ± one standard error.

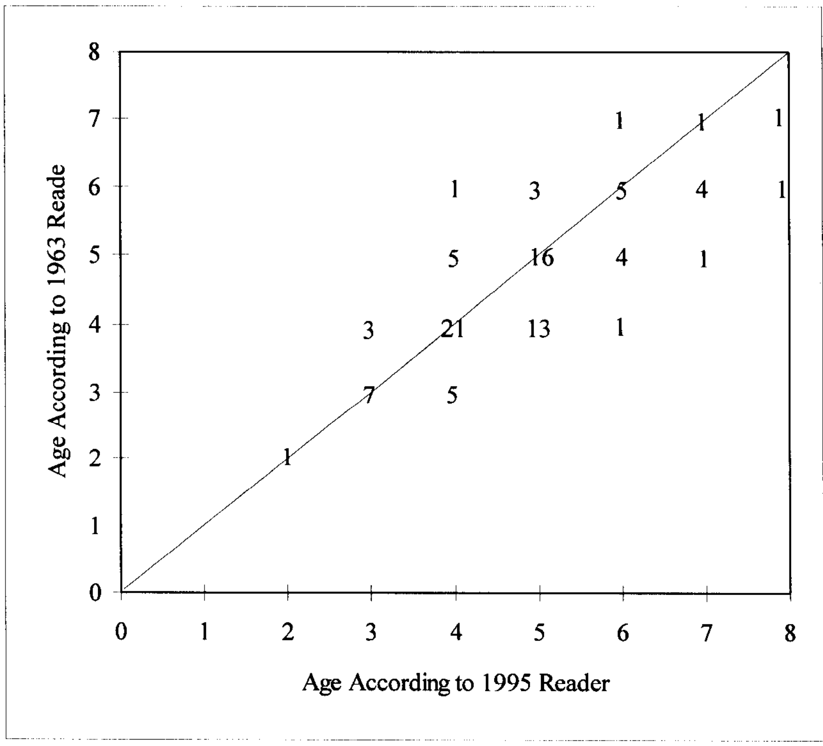

Figure 10.-Matrix of frequency of agreement by two readers for estimating ages of 100 otoliths selected randomly from the collection at Eva Creek in 1963. The numbers plotted are the number of otoliths at each age combination, and the line marks agreement on the ages. Six otoliths could not be aged by at least one reader.

Mean length at age increases smoothly for estimated ages ≤7 in 1995 (Table 1; Figure 11). Small sample size (N ≤7) and possible errors in aging suggest estimates for older fish are unreliable, especially when contrasted with estimates from 1963. Differences between the 1963 and 1995 results for fish age ≤7 might also result from differences in aging methods, as described above. However, results from the reader bias study suggest that significant differences in mean length at age in 1963 and 1995 exist regardless of the effects of bias in estimating age. As shown in Figure 11, bias in mean length at age for the 100 fish aged in both 1963 and 1995 (the study described above) is relatively insignificant for fish age 2-4, while estimates for fish age 5 and 6 are lower in 1995 (Figure 11), and sample sizes for fish age ≥7 are too small to be useful (Figure 10). Thus, the increase in mean length at age in 1995 relative to 1963 is accurate for fish age ≤4, conservative for fish age 5 and 6, and indeterminate for fish age ≥7.

MIGRANT CUTTHROAT TROUT

A total of 2,562 cutthroat trout were passed downstream though the weir (Appendix A3). Nearly all (2,535) trout were ≥180 mm FL. The first trout was captured on 21 April, the daily count peaked on 11 May, and the mid-point of the run occurred on 19 May (Figure 4). The run was relatively protracted, taking seven weeks from the 5th to 95th percentile of the run. Most of run occurred when while the water temperature was between 4.5 and 14°C. There was some, but not a strong, association between the daily count and gage height (Figure 5).

The length distribution of the 1995 sea-run cutthroat trout was bi-modal, with peaks in the 221-240 and 341-360 mm FL categories (Figure 12; Appendix A4). The mean FL of all sea-run trout was 303 mm, and the range was 141 to 485 mm (N=2,562). The mean weekly FL of sea-run cutthroat trout decreased steadily over time (Figure 13).

Obviously ripe trout (gametes spontaneously exuded during handling) were observed immediately, the last ripe trout was observed on 11 June, and 24% of all cutthroat trout passed downstream were ripe. The occurrence of ripe males peaked during the week of 15-21 May, and ripe females peaked a week later (Figure 14). A much larger proportion of the males were obviously ripe.

A total of 175 cutthroat trout were passed upstream during the weir's operation, and 94% of these had been tagged when passed downstream earlier. The first cutthroat was passed upstream on 10 June.

OTHER MIGRANTS

A total of 7,605 sockeye salmon *O. nerka*, 347 chum salmon *O. keta*, 173 pink salmon *O. gorbuscha*, 35 steelhead trout *O. mykiss*, and two rainbow trout *O. mykiss* were also passed upstream (Appendix A3). A total of 17 steelhead trout and 41 rainbow trout were also passed downstream.

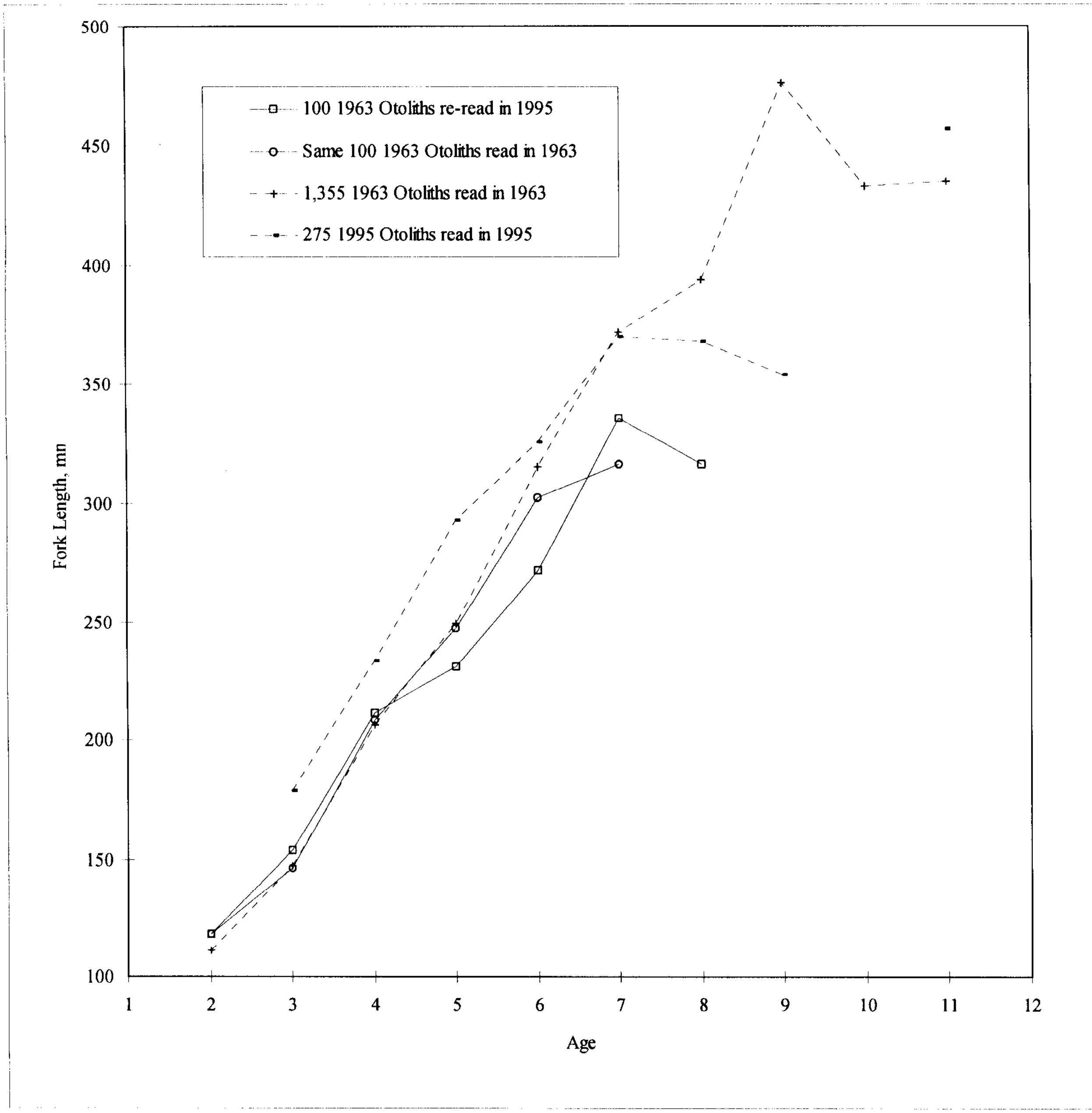

Figure 11.-Mean length at age estimates for Dolly Varden otoliths sampled in 1963 and 1995 at Eva Creek (+ and -), for 100 randomly-selected otoliths from 1963 that were re-read in 1995 (□ and o).

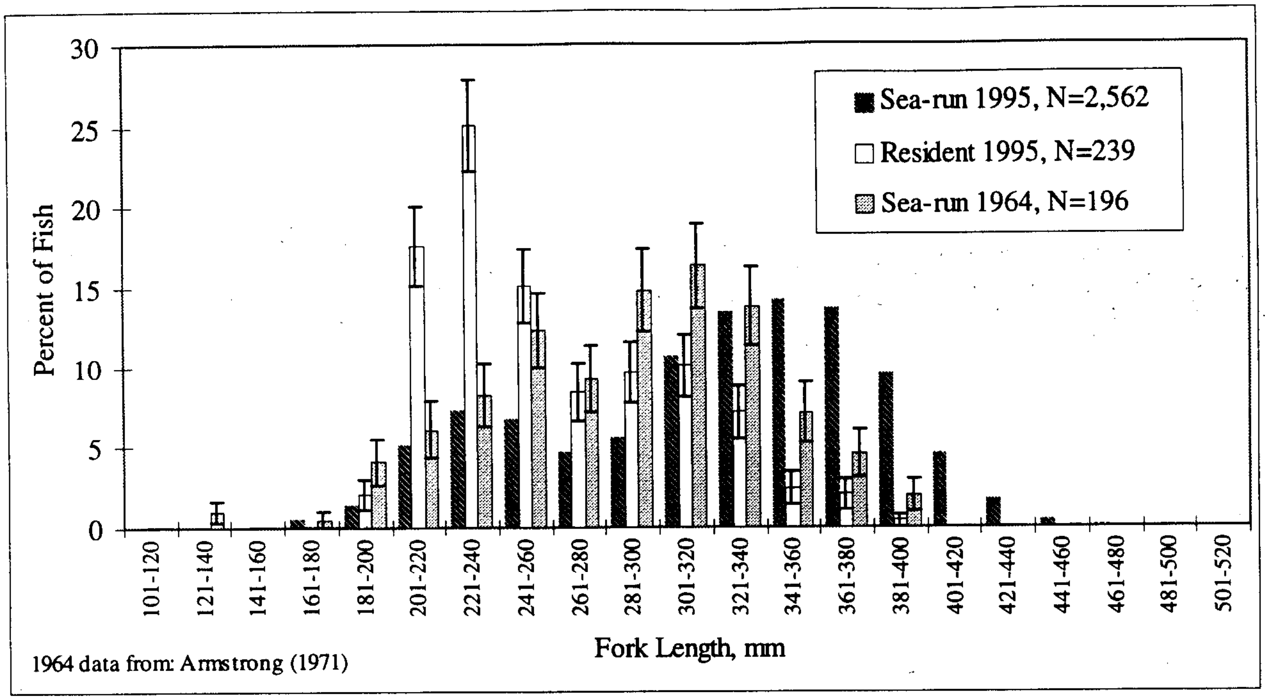

Figure 12.-Length frequency of 1995 sea-run, 1964 sea-run, and 1995 resident cutthroat trout in the Lake Eva system. Sea-run frequencies for 1995 are population statistics, the 1963 sea-run frequencies are estimates, and the resident fish frequencies are estimates based on samples from event 2 (error bars are ± one standard error).

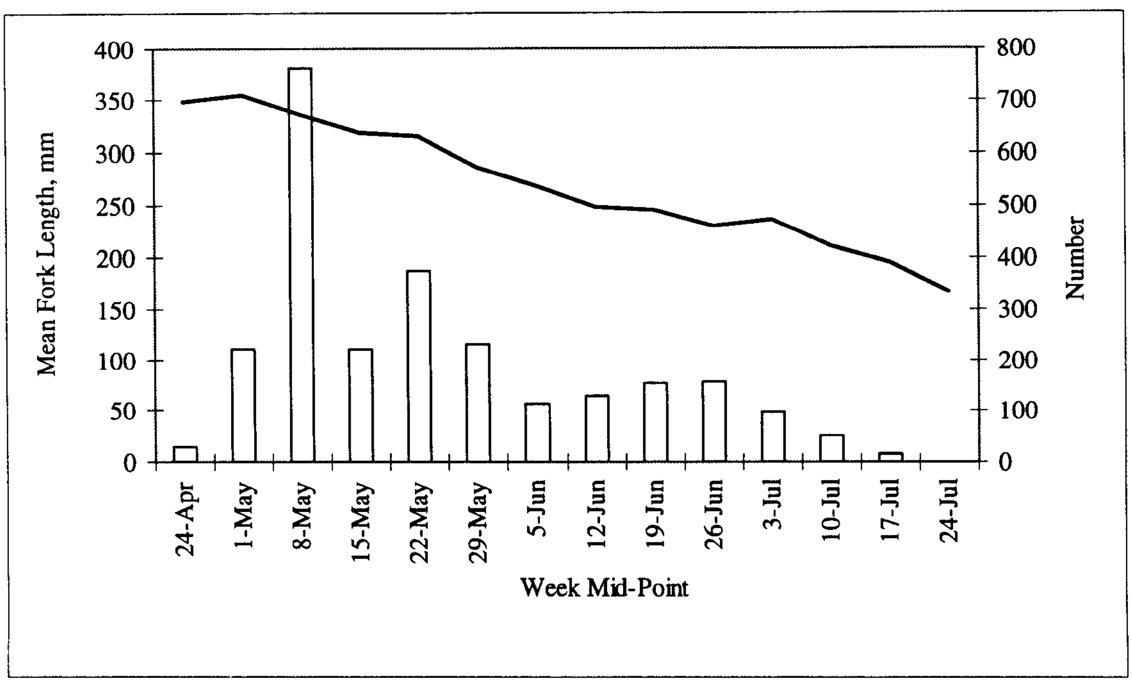

Figure 13.-Weekly mean fork lengths (lines) and numbers (bars) of sea-run cutthroat trout leaving Lake Eva during 1995.

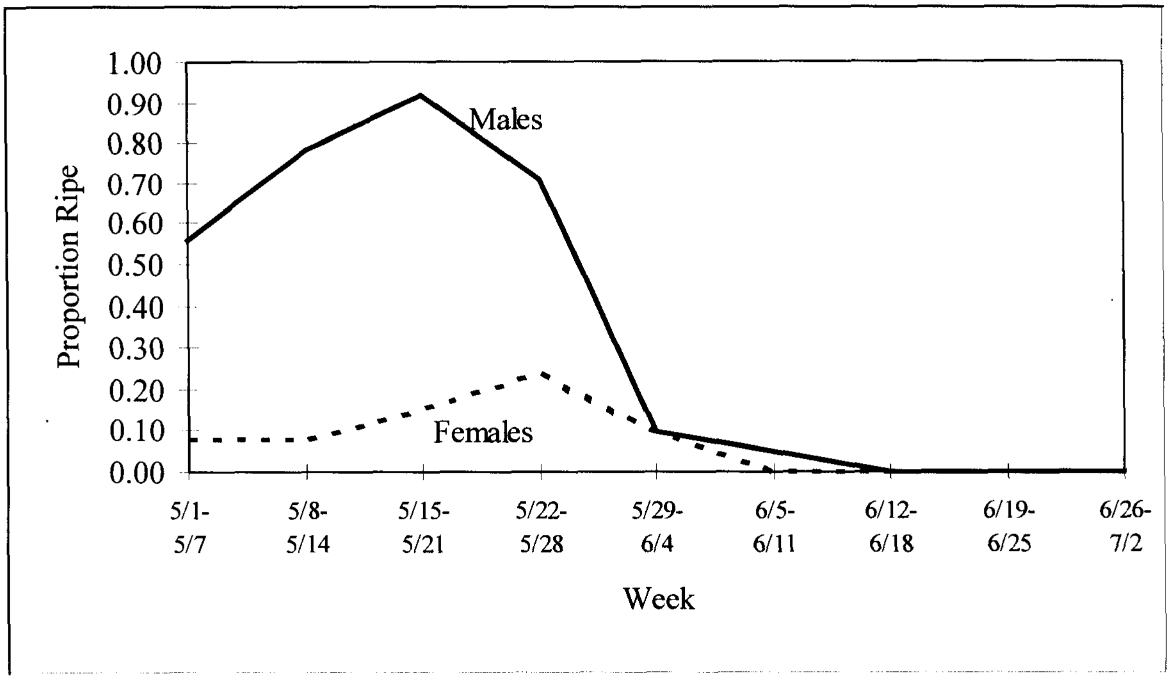

Figure 14.-Weekly proportion of obviously ripe, sea-run cutthroat trout passing downstream at the Eva Creek weir during 1995.

RESIDENT CUTTHROAT TROUT

A total of 798 cutthroat trout of all sizes were captured while sampling in Lake Eva, including multiple recaptures. Of these, 394 were unique (not captured more than once in a given event) trout ≥180 mm FL marked during event 1, 239 were unique trout ≥180 mm FL examined during event 2, and 43 of the 239 trout examined during event 2 were unique recaptures from event 1.

The catch per unit effort (CPUE) for both gear types was lower in event 2 than in event 1 for cutthroat trout ≥180 mm FL, but greater in event 2 for trout <180 mm FL (Table 2). Hook and line contributed more to the catch of cutthroat trout ≥180 mm FL than to the catch of cutthroat trout <180 mm FL. The mean FL of all sizes of hook and line caught trout (272 mm) was significantly larger (K-S test, $P<0.001$, $n_l=522$, $n_2=207$, $D_{max}=0.316$) than for fish caught in the traps (243 mm). The CPUE for cutthroat trout ≥180 mm FL decreased with depth, with a sharp drop in CPUE when depth was >10 m (Table 3). Almost all cutthroat trout <180 mm FL were captured at depths of 5 m or less. The mean FL of all cutthroat trout ≥180 mm FL captured was greatest at moderate depths (5.5-15 m).

None of the 239 trout ≥180 mm FL examined in event 2 had lost a tag. One mortality was observed in 798 cutthroat trout handled, so handling stress was considered negligible. Almost all fish were believed in “good” condition (no excessive injuries or delay in recovery).

Table 2.-Catch per unit effort (CPUE) and number caught with traps (fish per set) and hook and line (HL, fish per hour) by species and sampling event at Lake Eva during 1995. Includes redundant captures.

	Dolly Varden		Cutthroat Trout <180 mm FL		Cutthroat Trout ≥180 mm FL	
Event[a]	Trap	HL	Trap	HL	Trap	HL
			CPUE			
1	7.42	0.65	0.24	0.11	2.15	4.00
2	15.70	1.67	0.54	0.11	1.39	2.22
			Number Caught			
1	965	24	31	4	280	148
2	2,041	60	70	4	181	80
All	3,006	84	101	8	461	228

[a] The total effort for traps was 130 sets each for events 1 and 2, and for HL was 37 h for event 1 and 36 h for event 2.

Table 3.-Catch per unit effort (CPUE, fish per set) and mean fork length by depth for fish captured in traps at Lake Eva during 1995. CPUE statistics are based on sampling with replacement, and length statistics on sampling without replacement.

		Dolly Varden	Cutthroat Trout <180 mm FL	Cutthroat Trout ≥180 mm FL		
Depth, m	Number of Sets	CPUE	CPUE	CPUE	Mean FL (mm)	Number of trout
0-5	103	8.83	0.83	2.60	235	250
5.5-10	65	8.92	0.20	2.22	244	113
10.5-15	54	11.35	0	0.69	252	63
15.5-20	33	24.91	0.09	0.33	241	7
20.5-22	5	16.20	0	0.20	241	1
All	260	11.56	0.39	1.77	240	434

Five cutthroat trout tagged at the lake passed downstream through weir or were captured by hook and line between the lake and the weir. This was not a complete survey of emigration possibilities, but shows that emigration to a large alternative habitat (the outlet stream) was low (five in 394 marked during event 1). Thus, no adjustment for emigration was made.

A total of 36 sea-run cutthroat trout (trout marked at the weir) were captured in Lake Eva during mark-recapture sampling events 1 and 2. Since the weir never washed out, was operated during events 1 and 2, and every immigrating trout ≥180 mm FL was tagged, these immigrant trout were removed from the data and did not bias the population estimate. Without the weir, the population estimate for resident fish would have been biased high by about 5%, since 13 of 239 trout examined in event 2 were sea-run. Some immigration of resident trout may have occurred from the lake's tributaries, but it was assumed to be low and no adjustment was made.

The proportion of marked cutthroat trout in each area was not significantly different (X^2 test, P=0.99, df=2) among areas in event 2 (Table 4), even though mixing was not complete (Table 5). The length distributions for marked and recaptured cutthroat trout were not significantly different (K-S test, P=0.38, n_1=394, n_2=43, D_{max}=0.142; Figure 15), suggesting the second sampling event was not size selective. Thus, for all cutthroat trout ≥180 mm FL (i.e. pool all data), Chapman's modification of the Peterson model was used to estimate an abundance of 2,154 cutthroat trout with a standard error of 274 fish. The relative precision of the 95% confidence interval for the population estimate was 24.9%.

Because the length distributions of marked and examined trout were significantly different (K-S test, P=0.0067, n_1=394, n_2=239, D_{max}=0.136; Figure 15), only the length data from event 2 were used to estimate the resident population's length composition (Appendix A4). The peak of the length distribution for resident cutthroat trout occurred at the 221-240 mm FL category, with the adjacent size categories contributing the next largest proportions (Figure 12; Appendix A4). Sea-run cutthroat trout (mean FL 303 mm) were significantly larger (K-S test, P<0.001, n_1=2,542, n_2=300, D_{max}=0.520) than resident cutthroat trout ≥180 mm FL (mean FL 240 mm) during 1995.

The mean Sr/Ca ratio of Lake Eva water was 0.00435, half the salt water ratio of 0.0087 (Bruland 1983; Table 6). Because this is a marginal difference for this technique, and since Lake Eva cutthroat trout appeared to spend a small time in salt water (and thus may not acquire significantly increased marine Sr levels), otolith collection and analysis for this objective was discontinued.

A total of 3,006 Dolly Varden were also caught in Lake Eva (Table 2), but they were not marked when caught, so redundant captures (fish captured more than once) are unknown. Almost all of the Dolly Varden were captured by traps, and CPUE increased with depth, being the greatest in the two deepest strata (Table 3).

Table 4.-Numbers of cutthroat trout marked by area during event 1 and number sampled by mark status and area for event 2 at Lake Eva during 1995. The proportion of marked fish was not significantly different by area in event 2.

	Event 1	Event 2		
Area	Marked Fish	Marked Fish	Unmarked Fish	Marked %
1	127	20	90	18.2
2	152	13	61	17.6
3	115	10	45	18.2
Total	394	43	196	18.0

Table 5.-Number of cutthroat trout ≥180 mm FL marked in event 1 and recovered in event 2, by area, in Lake Eva during 1995. Fish did not move among the areas with equal probability, but did mix partially.

Area	Area Marked			
Recaptured	1	2	3	Total
1	10	6	4	20
2	4	9	0	13
3	0	3	7	10
Total	14	18	11	43

Table 6.-Concentrations ($mg{\cdot}L^{-1}$) of selected elements in Lake Eva water. MDL is method detection limit, and the control sample was distilled water.

	Sample		
Element	1-m Deep	15-m Deep	Control
Barium	0.012	0.012	<MDL
Calcuim	8.59	8.7	0.097
Magnesium	0.49	0.498	0.128
Potassium	<MDL	<MDL	<MDL
Sodium	1.59	1.54	1.09
Strontium	0.080	0.083	<MDL
Zinc	<MDL	0.004	0.008

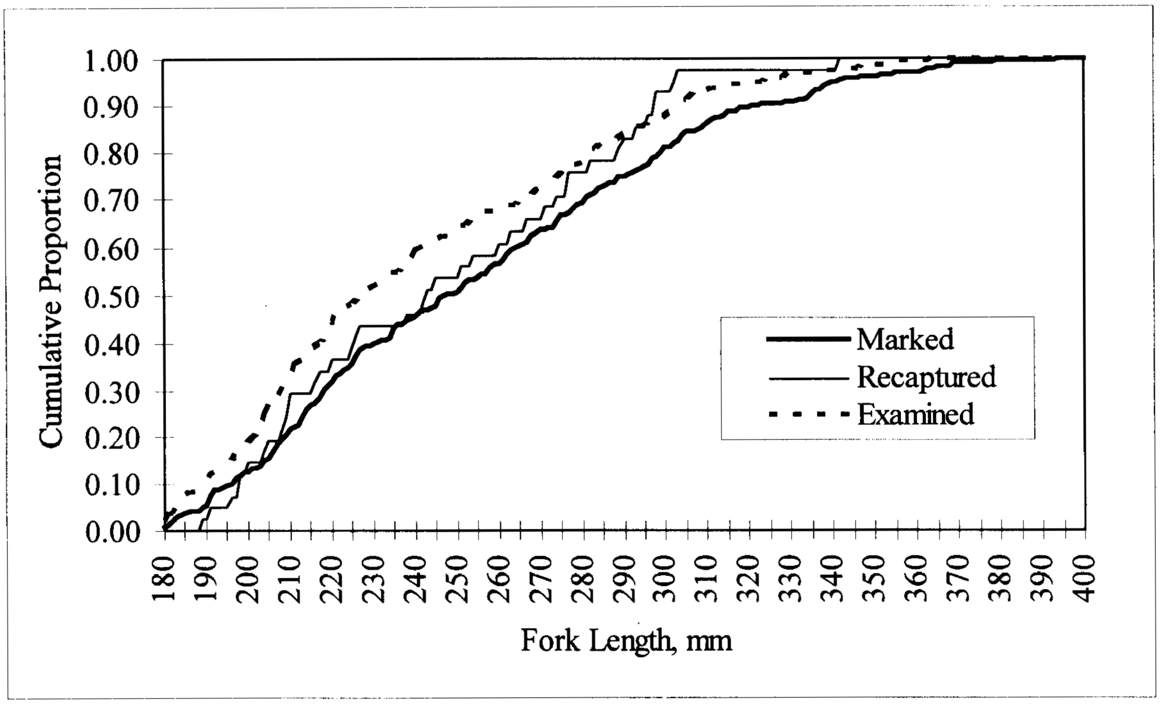

Figure 15.-Cumulative length distribution of marked, recaptured, and examined resident cutthroat trout sampled at Lake Eva during 1995. The length distributions of marked and recaptured trout were not significantly different, but the length distributions of marked and examined trout were significantly different.

DISCUSSION

The Dolly Varden emigration during 1995 (117,821) far exceeded the historical emigrations of 38,957 in 1962 and 93,303 in 1963 (Armstrong 1965). Variations in survival may not be the sole cause for the observed variations in abundance, since varying proportions of a given Dolly Varden population may overwinter at sea annually (Bernard et al. 1995). Also, because Dolly Varden have a high fidelity to their overwintering site (Armstrong 1965; Bernard et al. 1995), the "additional" fish observed in 1995 should not have been "strays" from other overwintering sites. Evaluating the health of a Dolly Varden population from a single year's data is risky, but the relatively high abundance observed in 1995 suggests the population is in excellent condition, relative to the 1960s.

The comparisons of parameter estimates for length and age of the Dolly Varden emigrants in 1963 and 1995 are complicated by differences in sampling and aging techniques. Mean length of the emigrants was much larger in 1995 (65 mm) after differences in sampling methodology were removed. Differences in age compositions were harder to resolve because of our limited commitment to re-aging large numbers of otoliths from 1963 so that reader bias could be accurately and precisely quantified. However, a limited analysis confirmed that Dolly Varden emigrating in 1995 tended to be older and larger as a result of abundant older age classes and that emigrants ≤6 years old were larger at age in 1995. An outstanding concern of the historical data, however, is the efficacy of the collection methods used, since they were not random or systematic. Any size-selective sampling from the weir traps (i.e. dip-net avoidance, time of day, or trap location) could certainly produce a biased sample. This was not an issue in 1995 because we used systematic sampling methods.

Differences in the length and age distributions between years are likely due to variations in recruitment (due to changing marine or freshwater conditions), a fundamental change in the productivity of the system, or human-induced harvest or habitat alterations. The combination of relatively fewer but significantly larger young (age ≤5) Dolly Varden in 1995 compared to 1963 is consistent with density-dependent effects on growth and survival for young Dolly Varden.

Lake Eva (105 ha) has a very high abundance of sea-run Dolly Varden for its size. Auke Lake (92 ha, near Juneau) Dolly Varden emigrations ranged from 3,052 to 11,728 fish (Doug Jones, Alaska Department of Fish and Game, Douglas, personal communication). Dolly Varden emigrations at Kook Lake (240 ha, Chichagof Island) ranged from 10,519 to 29,595 (David Barto, Alaska Department of Fish and Game, Douglas, personal communication). Sitkoh Lake (210 ha, Chichagof Island) had an emigration of 48,252 Dolly Varden during 1996 (Yanusz *in prep.*). Buskin Lake (101 ha, Kodiak Island), had Dolly Varden emigrations ranging from 30,725 to 90,600 fish (Whelan 1993). Why the Eva system, like the Buskin system, is so attractive to sea-run fish is not clear. Perhaps there is an exceptional abundance of high-quality spawning and over-summering habitat near these systems.

The emigration of sea-run cutthroat trout in 1995 (2,562) was almost double the historical emigrations of 1,594 in 1962, 1,210 in 1963, and 1,233 in 1964 (Armstrong 1971). Since both weirs effectively stopped the vast majority of fish, had few or no breaches by high water, and operated during the entire emigration, the methodology should not be biasing the counts. The timing of the mid-point of the cutthroat trout emigration in 1995 fell within the range of the historical data, which were 7 June 1962, 18 May 1963 and 10 June 1964 (Figure 4). We thus conclude the Lake Eva system is in exceptional health relative to the 1960s.

The mean FL of 303 mm for sea-run cutthroat trout in 1995 is larger than the mean FL of 284 mm in 1964 (Armstrong 1971). Since every migrant was measured during 1995, there is no sampling error associated with the 303 mm FL. However, the 1964 results were from a sample, for which a standard error was not reported. To estimate the variance of the mean FL for the 1964 data, samples of the size taken in 1964 were drawn from the length-frequency distribution reported in Armstrong (1971). The resulting estimated SE of about 4 mm suggests the apparent difference in mean FL between the two years is significant. Another concern is that the 1964 sampling was limited to between 27 May and 18 June 1964, which corresponds with the 11th and the 65th cumulative percentile of the trout emigration (Figure 4), and is not a representative sample. Also, the sampling in 1964 was uniform (20 fish every other day) and no weighting for the non-proportional sampling was made to generate an unbiased estimate for the portion of the population sampled (Armstrong 1971). The relationship between FL and date of emigration (Figure 13) would cause the 1964 mean FL to be biased high. Since the unbiased 1995 mean FL is greater than the high-biased 1964 mean FL, the observed difference of 19 mm (303-284 mm) actually underestimates the true difference, assuming the 1964 and 1995 emigrations had a similar trend in FL variation with emigration time (Figure 13). To estimate the influence of the truncated 1964 sampling scheme on the comparison, the identical sampling scheme (sampling the first 20 fish each day and the 11th through the 65th percentiles of the emigration) was applied to the 1995 FL data; the new estimate of 325 mm (as compared to 303 mm previously) suggests the actual difference between the means in 1964 and 1995 was more likely about 41 mm.

The bi-modal length distribution of the 1995 cutthroat trout emigration suggests strong year-class effects (Figure 12), which naturally result from changing marine and freshwater conditions, harvests, and/or habitat alterations. However, the fact that the smaller-size trout emigrated relatively late (Figure 13) suggests they may be smolt of sea-run trout (Behnke 1992; Trotter 1987). Relative differences in the strengths of the smolt populations is thus another explanation for the observed differences in the size distributions between years. In contrast, recent environmental conditions have been favorable for the growth and survival of other salmonids in Alaska, and sea-run cutthroat trout may have also benefitted. Interestingly, none of the sea-run fish in 1964 or 1995 exceeded 25 in total length (602 mm FL), the minimum size for "trophy" cutthroat trout under ADFG regulations.

Lake Eva (105 ha) has a very high abundance of sea-run cutthroat trout for its size. Auke Lake (92 ha, near Juneau) has had 190 to 937 emigrant cutthroat trout each spring (Doug Jones, Alaska Department of Fish and Game, Douglas, personal communication). Cutthroat trout emigrations at Kook Lake (240 ha, Chichagof Island) ranged from 345 to 564 fish (David Barto, Alaska Department of Fish and Game, Douglas, personal communication). Sitkoh Lake (210 ha, Chichagof Island) had an emigration of 3,955 cutthroat trout during 1996 (Yanusz *in prep.*). Why the Eva and Sitkoh systems are so attractive to sea-run trout is not clear. Again, there may be an exceptional abundance of high-quality spawning and over-summering habitat near these systems.

Cutthroat trout and Dolly Varden, whether sea-run or resident, are known to exhibit a wide range of life histories, even within the same system (Behnke 1992; Trotter 1987; Morrow 1980), and the Lake Eva populations show at least some of this variability. During winter, the majority of cutthroat trout in the Eva system are sea-run, and the Lake Eva sea-run trout reach a larger FL than do resident Lake Eva trout. Lake Eva, like some other overwintering locations in Southeast Alaska, is used for overwintering by stocks of cutthroat trout and Dolly Varden that spawn at many different locations (Doug Jones, Alaska Department of Fish and Game, Douglas, personal communication; Armstrong 1965). Fish with such a life history are vulnerable to harvests and habitat conditions well away from Lake Eva, and monitoring of the overwintering site may not be the best strategy to protect sea-run stocks (Armstrong 1984), as deficiencies of individual stocks may be difficult to detect unless individual components can be identified through tagging or genetic studies. Further comparisons of the many life-histories are restricted because sampling was limited to one season and a few gear types and locations, and as such cannot fully address the points above. However, it is clear that management strategies will need to address many considerations in order to be effective.

The life history of the sea-run cutthroat trout and Dolly Varden stocks may serve to reduce their harvests in the Eva system, and focus harvests onto the sea-run smolt and resident trout populations. We observed that most angling for trout at Lake Eva occurred during the summer, and most angling in Eva Creek was directed at sockeye salmon. Most sea-run trout and Dolly Varden exit the lake and creek prior to the arrival of these anglers. Anglers that did fish the creek in the spring were usually overwhelmed by the far more abundant Dolly Varden and caught relatively few trout. Sea-run trout leaving Lake Eva disperse to small, seldom-fished streams for spawning and apparently remain dispersed for the summer, whether in fresh water or salt water. Dolly Varden disperse similarly. We were not present at the Eva system to observe the angling pressure after 1 August 1995. The sea-run trout immigration has historically peaked during September (Armstrong 1971), and if anglers were attracted to the coho salmon run, then more sea-run trout and Dolly Varden may be incidentally harvested.

Using the current abundance estimate, Lake Eva's resident trout density of 21 trout/ha falls within the range of cutthroat trout densities in Southeast Alaska lakes, which range from about 2 to 38 trout/ha (Schmidt 1994; DerHovanesian and Marshall 1995). Further consideration of the abundance of resident cutthroat trout in Lake Eva during 1995 will be made when results from the Jolly-Seber experiment are available.

The percent of resident fish >336 mm FL in Lake Eva (the legal minimum size for "high use" lakes, ≥14 in total length) is 3%. Rigorous comparisons of the length distribution of resident cutthroat trout at Lake Eva and other populations are difficult due to the variety of sampling dates and times, sampling locations, reporting methods, and the effects of gear selectivity (DerHovanesian and Marshall 1995). However, the general appearance is that the length distribution of the Lake Eva trout population is about median compared to other Southeast Alaska trout populations (Schmidt 1994; Hoffman and Marshall 1994; Harding and Jones 1993; Jones et al. 1992; Jones and Harding 1991; Jones et al. 1990). Under current region-wide regulations for cutthroat trout (12 in total length or 287 mm FL minimum size limit), 79% of the sea-run cutthroat trout population would be available for harvest while in Eva Creek.

Very useful information about the life history of sea-run cutthroat trout might be gained if many radio-tracked trout were sacrificed for otolith Sr/Ca analysis after returning to their overwintering location. This would permit marine and spawning stream periods to be known and the usefulness of the Sr/Ca method could be quantified.

ACKNOWLEDGEMENTS

Bob Chadwick was the field crew leader and oversaw the quality of the data collected. Dan Peroni, Mike Villegas, Loyal Johnson, Mike Brase, Roger Hayward, and Chris Starostka performed the field sampling. Bob Marshall provided many useful comments during the manuscript preparation, and assisted in the study design and field work. John DerHovanesian also assisted in the study design. Richard Bloomquist, Gary Timothy, Jackie Timothy, Doug Jones, Roger Harding, Kurt Kondzela, and Rocky Holmes assisted in camp logistics and sampling. Anne Chadwick provided necessary radio relays with the field camp. One anonymous reviewer also commented on the manuscript.

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APPENDIX A

Appendix A1.-Location of historical data, and contents of report and raw data computer files used to produce this report.

File Name	Software	Contents
		Historical Data[a]
loc 20 J79808	hard copy	1962-64 Eva Creek weir counts
loc 21 J79809	hard copy	1963 Eva Creek Dolly Varden otolith and length data
		Report Files
evafds95.doc	Word 6.0	This entire document
		Raw data files
weir.xls	Excel 5.0	Tag numbers, sample numbers, ages, and lengths at weir for cutthroat trout and Dolly Varden
weirct.xls	Excel 5.0	Daily weir counts for all species
popest.xls	Excel 5.0	Trap and sport fishing catches, tag numbers, lengths and sample numbers at Lake Eva
sims.xls	Excel 5.0	Simulations used to estimate errors in historical data

[a] Located at: Alaska Department of Administration, Archives and Record Management Services, Juneau.

Appendix A2.-Detection of size-selective sampling.

Results of Hypothesis Tests (K-S) on Lengths of Fish MARKED during the First Event and RECAPTURED during the Second Event	Results of Hypothesis Tests (K-S) on Lengths of Fish CAPTURED during the First Event and CAPTURED during the Second Event
Case I: Accept Ho	Accept Ho
There is no size-selectivity during either sampling event.	
Case II: Accept Ho	Reject Ho
There is no size-selectivity during the second sampling event but there is during the first.	
Case III: Reject Ho	Accept Ho
There is size-selectivity during both sampling events.	
Case IV: Reject Ho	Reject Ho
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling
phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

From: Bernard and Hansen (1992)

Appendix A3.-Daily number of fish counted upstream or downstream, and the water temperature and depth at the Eva Creek weir during 1995.

Date	Depth cm	Temp-erature °C	Dolly Varden Down	Dolly Varden Up	Cutthroat Trout Down	Cutthroat Trout Up	Steelhead Trout Down	Steelhead Trout Up	Rainbow trout Down	Rainbow trout Up	Sockeye Salmon Up	Chum Salmon Up	Pink Salmon Up
4/14/95	31.0	2	2	0	0	0	0	0	0	0	0	0	0
4/15/95	27.5	2	2	0	0	0	0	0	0	0	0	0	0
4/16/95	27	2.5	84	0	0	0	0	0	0	0	0	0	0
4/17/95	31	3	47	0	0	0	0	0	0	0	0	0	0
4/18/95	29	2	112	0	0	0	0	0	0	0	0	0	0
4/19/95	27	3	13	0	0	0	0	0	0	0	0	0	0
4/20/95	26	3	12	0	0	0	0	0	0	0	0	0	0
4/21/95	26.5	3	205	0	1	0	0	0	0	0	0	0	0
4/22/95	32	3.5	309	0	5	0	0	0	0	0	0	0	0
4/23/95	40.5	3	467	0	4	0	0	0	0	0	0	0	0
4/24/95	41	3.5	520	0	5	0	0	0	1	0	0	0	0
4/25/95	42.5	4	279	0	0	0	0	0	0	0	0	0	0
4/26/95	45	4	1,255	0	7	0	0	0	0	0	0	0	0
4/27/95	50.5	4	800	0	7	0	0	0	0	0	0	0	0
4/28/95	59.5	4	3,522	0	20	0	0	0	1	0	0	0	0
4/29/95	61	4	1,049	0	10	0	0	0	1	0	0	0	0
4/30/95	62	3.5	962	0	17	0	0	0	0	0	0	0	0
5/1/95	61	4	2,017	0	52	0	0	0	1	0	0	0	0

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Appendix A3.-Page 2 of 6.

Date	Depth cm	Temp-erature °C	Dolly Varden Down	Dolly Varden Up	Cutthroat Trout Down	Cutthroat Trout Up	Steelhead Trout Down	Steelhead Trout Up	Rainbow trout Down	Rainbow trout Up	Sockeye Salmon Up	Chum Salmon Up	Pink Salmon Up
5/2/95	59	4.5	1,027	0	4	0	0	0	0	0	0	0	0
5/3/95	55	5	2,908	0	33	0	0	0	1	0	0	0	0
5/4/95	55	5	2,093	0	86	0	0	0	0	0	0	0	0
5/5/95	56	6	928	0	47	0	0	0	0	0	0	0	0
5/6/95	50	5	3,554	0	44	0	0	1	0	0	0	0	0
5/7/95	46	5	4,611	0	56	0	0	3	0	0	0	0	0
5/8/95	44.5	6	6,961	0	69	0	0	1	2	0	0	0	0
5/9/95	57	7	6,187	0	106	0	0	5	2	0	0	0	0
5/10/95	62.5	7	4,222	0	108	0	0	5	0	0	0	0	0
5/11/95	69.5	7	8,548	0	334	0	0	5	7	0	0	0	0
5/12/95	60	7	1,281	0	13	0	0	4	4	0	0	0	0
5/13/95	67	7	3,010	0	29	0	0	0	1	0	0	0	0
5/14/95	64	7	1,498	0	13	0	0	2	0	0	0	0	0
5/15/95	59	7	1,099	0	14	0	0	0	0	0	0	0	0
5/16/95	51	8	598	0	122	0	0	0	0	0	0	0	0
5/17/95	48.5	7	555	0	29	0	0	0	0	0	1	0	0
5/18/95	41	7	215	0	1	0	0	0	0	0	0	0	0
5/19/95	38	7	2,617	0	80	0	0	0	0	0	0	0	0
5/20/95	38	8	1,787	0	30	0	0	0	1	0	0	0	0
5/21/95	40	8	2,928	0	73	0	0	0	0	0	0	0	0

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Appendix A3.-Page 3 of 6.

Date	Depth cm	Temp-erature °C	Dolly Varden		Cutthroat Trout		Steelhead Trout		Rainbow trout		Sockeye Salmon	Chum Salmon	Pink Salmon
			Down	Up	Down	Up	Down	Up	Down	Up	Up	Up	Up
5/22/95	41	8	3,793	0	89	0	0	0	2	0	0	0	0
5/23/95	42	8	1,747	0	43	0	0	2	0	0	0	0	0
5/24/95	43	9	3,619	0	41	0	0	0	1	0	0	0	0
5/25/95	48.5	9	5,392	0	19	0	0	0	0	0	0	0	0
5/26/95	50	10	8,828	0	106	0	1	1	0	0	0	0	0
5/27/95	54	10	11,213	0	54	0	0	1	1	0	1	0	0
5/28/95	53	10	1,362	0	47	0	0	1	0	0	1	0	0
5/29/95	55	10.5	1,069	0	10	0	2	0	0	0	0	0	0
5/30/95	41	7	163	0	3	0	0	1	0	0	0	0	0
5/31/95	44	8	1,185	0	14	0	2	1	1	0	0	0	0
6/1/95	42	8.5	359	1	0	0	1	0	0	0	0	0	0
6/2/95	41	8.5	327	0	4	0	1	0	0	0	0	0	0
6/3/95	41.5	9	321	0	2	0	0	0	0	0	0	0	0
6/4/95	80	9	7,420	0	68	0	3	2	5	0	1	0	0
6/5/95	61.5	9	155	0	11	0	0	0	1	0	7	0	0
6/6/95	46	9	68	0	5	0	0	0	0	0	0	0	0
6/7/95	41	8.5	234	0	21	0	0	0	2	0	1	0	0
6/8/95	40	9	3	0	0	0	0	0	0	0	3	0	0
6/9/95	41.5	10	520	0	22	0	0	0	1	0	3	0	0
6/10/95	48	11	495	0	19	4	1	0	1	1	3	0	0

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Appendix A3.-Page 4 of 6.

Date	Depth cm	Temperature °C	Dolly Varden Down	Dolly Varden Up	Cutthroat Trout Down	Cutthroat Trout Up	Steelhead Trout Down	Steelhead Trout Up	Rainbow trout Down	Rainbow trout Up	Sockeye Salmon Up	Chum Salmon Up	Pink Salmon Up
6/11/95	52	12	133	0	52	3	0	0	1	0	18	0	0
6/12/95	47	11	42	0	19	4	0	0	1	0	36	0	0
6/13/95	42	11.5	10	0	6	0	0	0	0	0	2	0	0
6/14/95	38	10	19	0	6	12	0	0	0	0	0	0	0
6/15/95	34	10	12	0	5	1	0	0	0	0	0	0	0
6/16/95	30.5	10	17	0	25	6	0	0	0	0	31	0	0
6/17/95	28	9.5	256	0	24	5	0	0	0	0	22	0	0
6/18/95	30.5	10.5	31	0	10	0	0	0	0	0	2	0	0
6/19/95	29	11	74	3	7	0	0	0	1	0	0	0	0
6/20/95	28	10.5	31	6	0	1	0	0	1	0	325	0	0
6/21/95	29	12	53	1	33	1	0	0	0	0	26	0	0
6/22/95	29.5	12	95	16	54	1	0	0	0	0	435	0	0
6/23/95	34.5	12	125	1	54	1	4	0	0	0	35	0	0
6/24/95	30	12	32	43	31	15	0	0	1	1	10	0	0
6/25/95	29.5	12	40	103	25	18	0	0	0	0	415	0	0
6/26/95	26	11.5	14	32	9	3	0	0	0	0	23	0	0
6/27/95	25	12	2	55	14	4	0	0	0	0	180	0	0
6/28/95	24.5	12	17	89	6	2	0	0	0	0	60	0	0
6/29/95	26	12	23	139	17	4	0	0	0	0	379	0	0
6/30/95	26.5	12.5	40	158	17	11	0	0	0	0	136	0	0

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Appendix A3.-Page 5 of 6.

Date	Depth cm	Temp-erature °C	Dolly Varden Down	Dolly Varden Up	Cutthroat Trout Down	Cutthroat Trout Up	Steelhead Trout Down	Steelhead Trout Up	Rainbow trout Down	Rainbow trout Up	Sockeye Salmon Up	Chum Salmon Up	Pink Salmon Up
7/1/95	28	14	7	99	10	4	0	0	0	0	606	1	0
7/2/95	26	12.5	12	22	14	3	0	0	0	0	71	0	0
7/3/95	26	12.5	15	139	6	2	0	0	0	0	5	0	0
7/4/95	23.5	14	13	395	12	6	0	0	0	0	483	0	0
7/5/95	22.5	14.5	16	153	19	3	2	0	0	0	60	0	0
7/6/95	22.5	14	8	165	20	5	0	0	0	0	407	0	0
7/7/95	21	14.5	15	47	10	2	0	0	0	0	60	0	0
7/8/95	20	14	11	243	6	4	0	0	0	0	106	0	0
7/9/95	20	14	13	453	3	4	0	0	0	0	86	0	0
7/10/95	19	15	4	562	5	5	0	0	0	0	143	1	0
7/11/95	20	14.5	6	1023	6	4	0	0	0	0	109	0	0
7/12/95	19	15	12	690	9	2	0	0	0	0	118	1	0
7/13/95	19.5	15	6	594	13	2	0	0	0	0	156	1	0
7/14/95	20.5	14.5	11	223	12	1	0	0	0	0	153	6	0
7/15/95	19	15	0	516	0	3	0	0	0	0	135	8	0
7/16/95	19	14.5	2	181	2	1	0	0	0	0	92	16	0
7/17/95	19	15	2	435	3	2	0	0	0	0	230	20	0
7/18/95	18	15	1	134	0	5	0	0	0	0	35	2	0
7/19/95	17	14	1	92	0	1	0	0	0	0	182	11	0

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Date	Depth cm	Temp-erature °C	Dolly Varden		Cutthroat Trout		Steelhead Trout		Rainbow trout		Sockeye Salmon	Chum Salmon	Pink Salmon
			Down	Up	Down	Up	Down	Up	Down	Up	Up	Up	Up
7/20/95	17	13.5	5	303	0	0	0	0	0	0	354	20	0
7/21/95	16	14.5	14	758	1	5	0	0	0	0	104	4	0
7/22/95	17	15	3	606	0	1	0	0	0	0	59	0	0
7/23/95	16.5	15	7	610	0	2	0	0	0	0	79	27	0
7/24/95	17	14.5	3	832	0	2	0	0	0	0	148	75	5
7/25/95	31.5	15	0	3,105	0	1	0	0	0	0	479	20	33
7/26/95	28	14	4	177	0	4	0	0	0	0	214	7	3
7/27/95	22	14	0	275	0	0	0	0	0	0	356	32	2
7/28/95	20	13.5	7	210	0	1	0	0	0	0	125	24	13
7/29/95	17	14	0	258	0	3	0	0	0	0	102	11	36
7/30/95	17	14	0	204	0	1	0	0	0	0	85	32	61
7/31/95	17	14	0	45	0	0	0	0	0	0	107	28	20
Total			117,821	14,196	2,562	175	17	35	41	2	7,605	347	173

Appendix A4.-Estimated proportions (p) by fork length category *i* of emigrant, sea-run Dolly Varden and resident cutthroat trout at Lake Eva during 1995 and sea-run Dolly Varden during 1963. Resident cutthroat trout proportions were calculated by sampling without replacement during event 2.

Fork Length Category *i* (mm)	1995 Sea-run Dolly Varden[a] p_i	N	1995 Sea-run Cutthroat Trout[a] p_i	N	1995 Resident Cutthroat Trout[b] p_i	N	1963 Sea-run Dolly Varden[c] p_i	N
61-80		0		0		0		0
81-100	0.003	2		0		0		0
101-120		0		0		0		0
121-140		0		0		0	0.011	15
141-160		0	0.00	1		0	0.033	46
161-180	0.003	2	0.01	15		0	0.035	49
181-200	0.027	16	0.01	38	0.021	5	0.044	62
201-220	0.054	32	0.05	132	0.176	42	0.120	168
221-240	0.069	41	0.07	187	0.251	60	0.178	249
241-260	0.105	62	0.07	170	0.151	36	0.136	191
261-280	0.100	59	0.05	120	0.084	20	0.084	118
281-300	0.069	41	0.06	144	0.096	23	0.060	84
301-320	0.076	45	0.11	270	0.100	24	0.061	85
321-340	0.102	60	0.13	342	0.071	17	0.048	67
341-360	0.080	47	0.14	362	0.025	6	0.038	53
361-380	0.076	45	0.14	347	0.021	5	0.034	48
381-400	0.066	39	0.10	244	0.004	1	0.037	52
401-420	0.049	29	0.05	117		0	0.026	37
421-440	0.052	31	0.02	45		0	0.023	32
441-460	0.025	15	0.00	12		0	0.011	16
461-480	0.015	9	0.00	3		0	0.008	11
481-500	0.012	7	0.00	1		0	0.006	8
501-520	0.003	2	0.00	1		0	0.004	6
521-540	0.003	2		0		0	0.001	1
541-560	0.003	2		0		0	0.001	1
561-580		0		0		0		0
581-600	0.002	1		0		0	0.001	1
601-621	0.002	1		0		0		0
621-640	0.002	1		0		0		0
All		591		2,551		239		1,400

[a] sampled at weir

[b] sampled at lake

[c] data from Alaska Department of Administration, Archives and Record Management Services, and includes 45 Dolly Varden which were measured but had unreadable otoliths